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The genus *Allocetraria* (*Parmeliaceae*) in China

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Abstract—Ten species of *Allocetraria* are reported from China, including the new species *Allocetraria corrugata*, which is characterized by strongly rugose upper and lower lobe surfaces. A phylogenetic analysis based on nrDNA ITS sequences supports the independence of the new taxon. Diagnostic characters and distribution of the *Allocetraria* species occurring in China are given, and a key to the identification of the species is provided.

Key words— cetrarioid lichens, chemistry, comprehensive analysis, morphology, taxonomy

Introduction

The lichenized genus *Allocetraria* Kurok. & M.J. Lai, which was described in 1991, comprised two species from other genera (the type, *A. stracheyi,* and *A. ambigua*) and one new species, *A. isidiigera.* The genus was originally characterized by dichotomously or subdichotomously branched lobes and foliose to suberect or erect thallus with sparse rhizines, angular to sublinear pseudocyphellae, a palisade plectenchymatous upper cortex, and the presence of usnic acid in the cortex (Kurokawa & Lai 1991). Randlane & Saag (1992) later transferred three additional taxa—*A. cucullata*, *A. nivalis*, and *A. potaninii*—based on morphological, anatomical, and chemical data. Subsequently, Kärnefelt et al. (1994) transferred *A. cucullata* and *A. nivalis* into a new genus *Flavocetraria*, distinguished from *Allocetraria* based on ascus structure and ascospore morphology.

Thell et al. (1995) described two additional new *Allocetraria* species and transferred three species from other genera—*A. flavonigrescens*, *A. sinensis*, *A. denticulata*, *A. globulans,* and *A. oakesiana*—and synonymized *A. potaninii* with *A. stracheyi*. At that time the genus was diagnosed as having a palisade plectenchymatous cortex, asci with a very broad axial body, globose or

subglobose ascospores, and filiform conidia (Thell et al. 1995). Later, Kärnefelt & Thell (1996) transferred two additional species to *Allocetraria*—*A. endochrysea* and *A. madreporiformis*.

Lai et al. (2007) established a new genus *Usnocetraria* and transferred numerous *Allocetraria* species into the new genus (all but two as invalidly published combinations). However, Thell et al. (2009) demonstrated that none of these species was closely related to the type species *Usnocetraria oakesiana* [≡ *Allocetraria oakesiana*]. Recently, Wang et al. (2014) described a new species *Allocetraria capitata* characterized by having capitate soralia on the top of lobes. During our taxonomic study of *Allocetraria*, we have identified an additional new species, which brings to ten the number of species accepted in the genus *Allocetraria*.

In its current circumscription *Allocetraria* is a well-supported monophyletic group within the cetrarioid clade (Saag et al. 2002, Thell et al. 2009, Nelsen et al. 2011), and China is the distribution center of the genus, with all ten species known to occur in China. An overview and a key to all ten *Allocetraria* species are provided below.

Materials & methods

Phenotypic study

A total of over 1000 specimens of *Allocetraria* from mainland China were examined. A dissecting microscope (Zeiss Stemi SV11) and compound microscope (Zeiss Axioskop 2 plus) were used to study the morphology and anatomy. All specimens are conserved in Herbarium Mycologium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS).

Color test reagents (10% aqueous KOH, saturated aqueous $Ca(OCl)_2$, and concentrated alcoholic *p*-phenylenediamine) and thin-layer chromatography (TLC, solvent system C) were used to detect lichen substances (Culberson & Kristinsson 1970, Culberson 1972).

DNA extraction & PCR amplification

Twenty-seven freshly collected lichen specimens were chosen for DNA extraction (Table 1). The extraction procedure followed a modified CTAB method (Rogers & Bendich 1988). PCR amplifications were performed using a Biometra T-Gradient thermal cycler. The primer pairs ITS1 (White et al. 1990) and LR1 (Vilgalys & Hester 1990) were used to amplify the nrDNA ITS region. Reactions were carried out in 25 µl reaction volumes containing 0.5 µL total DNA, 1 µL each primer (10µM), 0.5 µL Taq polymerase (BIOTAQ_ DNA Polymerase, 3U/µL), 2.5 µL dNTP (10µM), 2.5 µL amplification buffer (10×), 2.0 µL $MgCl_2$, and 16 µL ddH_2O. Cycling parameters comprised an initial denaturation at 94°C for 5 min, 35 cycles of denaturation at 94°C for 50 s, annealing at 50–53°C for 50 s, extension at 72°C for 1 min, and a final extension at 72°C for 5 min.

Table 1. Specimens of *Allocetraria* spp. and outgroups used in the phylogenetic analysis

Species	Voucher	Locality	GenBank no.
A. ambigua	Wang BM12059	China	KF923756
	Zhang Z11136	China	KF923757
	Zhang Z11139	China	KF923758
	Zhang Z11144	China	KF923759
	Zhang Z11145	China	KF923762
A. corrugata	Wang YK12033	China	KF923760
A. endochrysea	Wang BM12011	China	KF923763
	Wang YK12003	China	KF923764
	Wang YK12010	China	KF923765
A. flavonigrescens	Zhang Z11121	China	KF923768
	Wei & Chen QH12058	China	KF923769
	Wei & Chen QH12407	China	KF923770
	Wei & Chen QH12909	China	KF923771
	Wei & Chen QH12114	China	KF923772
	Wang BM12062	China	KF923773
**A. flavonigrescens*	Obermayer 08140	China	AF404127
**A. globulans*	Obermayer 08137	China	AF404126
A. madreporiformis	Wei 125691	China	KF923774
A. sinensis	Wang YK12008	China	KF923775
	Wang YK12025	China	KF923776
**A. sinensis*	Obermayer 08148	China	AF404125
A. stracheyi	Wang BM12029	China	KF923777
	Wang YK12005	China	KF923778
	Wang YK12009	China	KF923779
	Wang YK12016	China	KF923780
	Wang YK12030	China	KF923781
	Wang DQ12432	China	KF923782
**A. stracheyi*	Obermayer 143	China	JX144031
**A. ambigua*	Obermayer 08141	China	AF404128
**A. madreporiformis*	Obermayer 7746	Austria	AF416460
**Tuckermanopsis ciliaris*			HQ650615
**Usnocetraria oakesiana*		Germany	EU401757
Vulpicida juniperina	Cao et al. HY11-243	China	KF923786

* ITS sequences downloaded from GenBank. (All other sequences were obtained by the authors from specimens deposited in HMAS-L.)

DNA sequencing & phylogenetic analysis

PCR products were sequenced using ABI 3700 Sequencer (Shanghai Boshang Corporation) and analyzed phylogenetically with software Mega5 (Tamura et al. 2011). The K2+G model was set according to the lowest BIC (Bayesian Information Criterion) scores. NrDNA ITS sequences of 27 specimens were generated, and 9 sequences were downloaded from GenBank (Table 1). Three genera included in the cetrarioid clade (*Tuckermanopsis ciliaris* (Ach.) Gyeln., *Usnocetraria oakesiana* (Tuck.) M.J. Lai & J.C. Wei, *Vulpicida juniperina* (L.) J.-E. Mattsson & M.J. Lai) were used as outgroup. The phylogenetic tree was inferred by maximum likelihood (ML), and the reliability of the inferred tree was tested by 1000 bootstrap replications. The intraspecific and interspecific genetic distances of the *Allocetraria* species were also calculated and compared.

Results & discussion

Phylogenetic analyses

Eight species of *Allocetraria*, including the new species, were included in our phylogenetic analysis. *Allocetraria capitata* and *A. isidiigera* are not included because we were unable to obtain fresh material. The ITS-based ML tree (Fig. 1) indicates that the 8 *Allocetraria* species form a well-supported (88% bootstrap value) monophyletic clade. Each species for which more than one specimen was included also formed a monophyletic clade. The backbone of the topology only received moderate support; additional loci will be necessary to address the phylogenetic relationships within the genus. However, the genetic distances (Table 2) based on nrDNA ITS sequences within *Allocetraria* provided more information. According to Del Prado et al. (2010), the distance based on the nrDNA ITS sequences of parmelioid lichens in *Parmeliaceae* (one of the largest lichenized families) has been shown to serve as a powerful tool for identifying species complexes. In our analysis of *Allocetraria*, the intraspecific distance range was 0–0.010 (most <0.006), while the interspecific distance range was 0.014–0.089. The closest distance of *A. corrugata* was to *A. flavonigrescens* (0.028), which was well separated from other species of *Allocetraria*.

Morphology & chemistry

The *Allocetraria* thallus is characterized as foliose to subfruticose, dorsiventral or with radially symmetric branches, dichotomously or subdichotomously branched; upper surface yellow, greenish yellow, or brown; lobes flat, suberect to erect; pseudocyphellae angular or sublinear, marginal along the lower surface; sorediate or isidiate; lower surface wrinkled, yellowish, brown, or black; sparsely rhizinate; medulla white, yellowish, or orange yellow. Apothecia rare, terminal; 8 ascospores per asci, simple, near globose, 4–10 μm in diameter; pycnidia marginal, immersed or on emergent projections; pycnoconidia

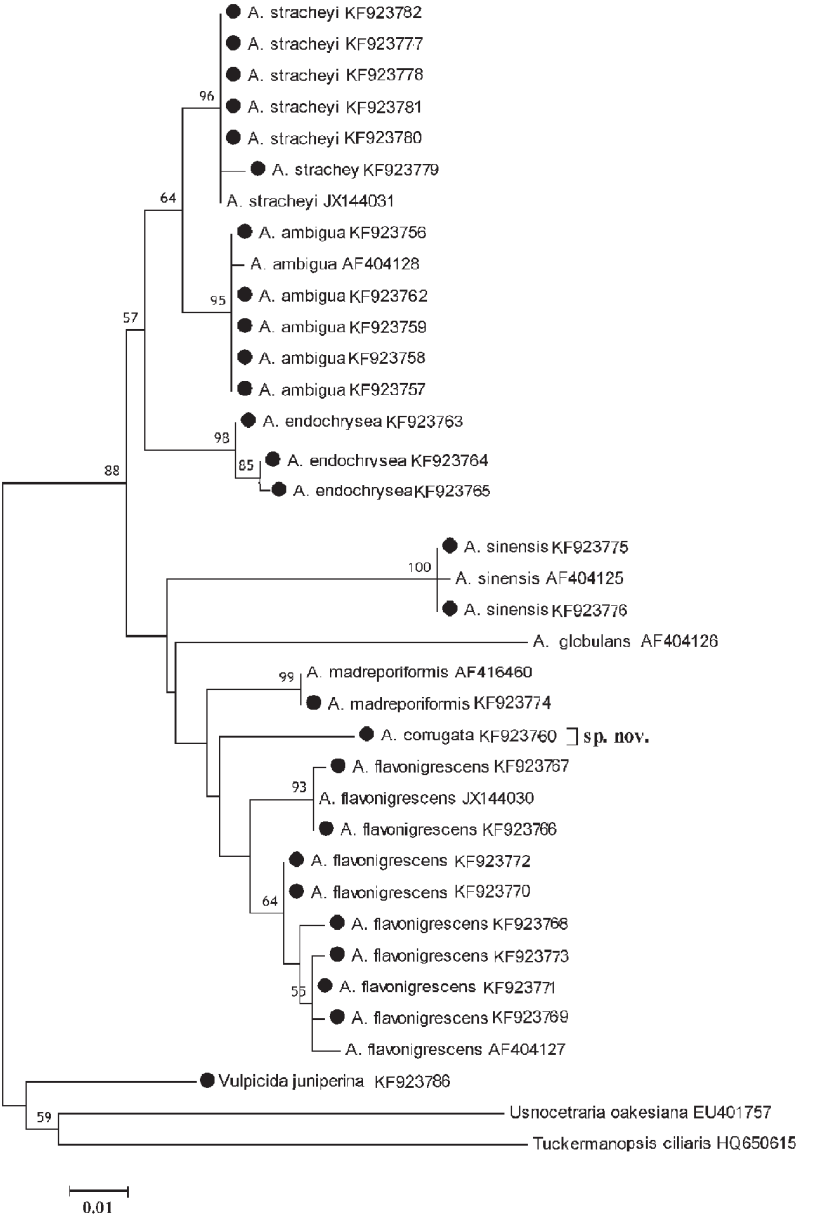

Fig. 1. The maximum likelihood tree based on nrDNA ITS region sequences of *Allocetraria* spp. The samples marked with '●' were examined by the authors. The numbers at each node represent bootstrap support values ≥50.

Table 2. Intraspecific and interspecific genetic distances range of the *Allocetraria* species

Species	1	2	3	4	5	6	7	8
1 *A. ambigua*	0–0.002							
2 *A. corrugata*	0.045	—						
3 *A. endochrysea*	0.024–0.026	0.045–0.049	0.002–0.006					
4 *A. flavonigrescens*	0.030–0.035	0.028–0.036	0.032–0.042	0.002–0.010				
5 *A. globulans*	0.057–0.059	0.075	0.069–0.073	0.057–0.073	—			
6 *A. madreporiformis*	0.038–0.039	0.032	0.042–0.047	0.026–0.034	0.069	0		
7 *A. sinensis*	0.059–0.063	0.057–0.061	0.059–0.067	0.048–0.057	0.079–0.081	0.059–0.063	0–0.002	
8 *A. stracheyi*	0.014–0.020	0.047–0.051	0.024–0.030	0.032–0.040	0.065	0.040–0.045	0.056–0.061	0–0.004

Notes: The numbers in the first row indicate the different species listed in column 1;
— indicates no range because of single sample.

Table 3. Diagnostic characters of *Allocetraria* species

Species	Soredia / isidia	Medulla	Conidial length	Chemistry	Substrate
A. ambigua	Absent	White	c. 15 µm	Usnic, lichesterinic, protolichesterinic, secalonic acids	Terricolous, corticolous
A. capitata	Capitate soralia	Yellowish to yellow	c. 15 µm	Usnic, fumarprotocetraric, protocetraric, secalonic acids	Terricolous
A. corrugata	Absent	White	<30 µm	Usnic, fumarprotocetraric, protocetraric acids	Saxicolous
A. endochrysea	Absent	Yellow	c. 15 µm	Usnic, lichesterinic, protolichesterinic acids, dufourin, endochrysin	Terricolous, corticolous
A. flavonigrescens	Absent	White	c. 15 µm	Usnic, fumarprotocetraric, protocetraric acids	Terricolous, corticolous
A. globulans	Absent	White	c. 15 µm	Usnic, lichesterinic, protolichesterinic, secalonic acids	Terricolous, corticolous
A. isidiigera	Isidiate	White	c. 15 µm	Usnic, fumarprotocetraric, protocetraric acids	Corticolous
A. madreporiformis	Absent	White	c. 15 µm	Usnic, lichesterinic acids	Terricolous
A. sinensis	Absent	White	c. 15 µm	Usnic, lichesterinic, protolichesterinic, secalonic acids	Terricolous, saxicolous
A. stracheyi	Absent	Yellowish to yellow	c. 15 µm	Usnic, lichesterinic, protolichesterinic, secalonic acids	Terricolous, corticolous, saxicolous

filiform, 0.5–2×10–25(–30) µm. Both cortices are palisade plectenchymatous or paraplectenchymatous. Usnic acid is present in the cortex, while lichesterinic and protolichesterinic fatty acids are common in the medulla; secalonic acid occurs in several, and dufourin, endochrysin, fumarprotocetraric acid or protocetraric acid in some species.

The new species, *A. corrugata,* is diagnosed as having long conidia, numerous black spots on the margin and upper surface, and strongly rugose upper and lower lobe surfaces. It has the same secondary metabolites as *A. isidiigera* but differs in its flat lobes, an obviously rugose upper surface, and longer conidia (Table 3).

All *Allocetraria* species contain usnic acid, and most contain lichesterinic and protolichesterinic acids. *Allocetraria endochrysea* is characterized by containing dufourin and endochrysin in the medulla. The fumarprotocetraric acid chemosyndrome occurs in *A. corrugata*, *A. flavonigrescens* and *A. isidiigera*. Secalonic acid is found in *A. ambigua*, *A. capitata*, *A. globulans*, *A. sinensis* and *A. stracheyi*.

Key to the ten species of *Allocetraria* in China

1. Thallus subfruticose to near columnar 2
1. Thallus foliose 3

2. Medulla white ..... *A. madreporiformis*
2. Medulla yellow ..... *A. endochrysea*

3. Isidia or soredia present 4
3. Isidia and soredia absent 5

4. Isidia present, medulla PD+ ..... *A. isidiigera*
4. Capitate soralia present, medulla PD– ..... *A. capitata*

5. Medulla PD+ ..... *A. flavonigrescens*
5. Medulla PD– 6

6. Conidia up to 25–30 µm long ..... *A. corrugata*
6. Conidia up to 15 µm long 7

7. Isidia-like lobules present ..... *A. stracheyi*
7. Isidia-like lobules absent 8

8. Lower surface yellowish ..... *A. ambigua*
8. Lower surface brown to black 9

9. Thallus erect ..... *A. globulans*
9. Thallus procumbent ..... *A. sinensis*

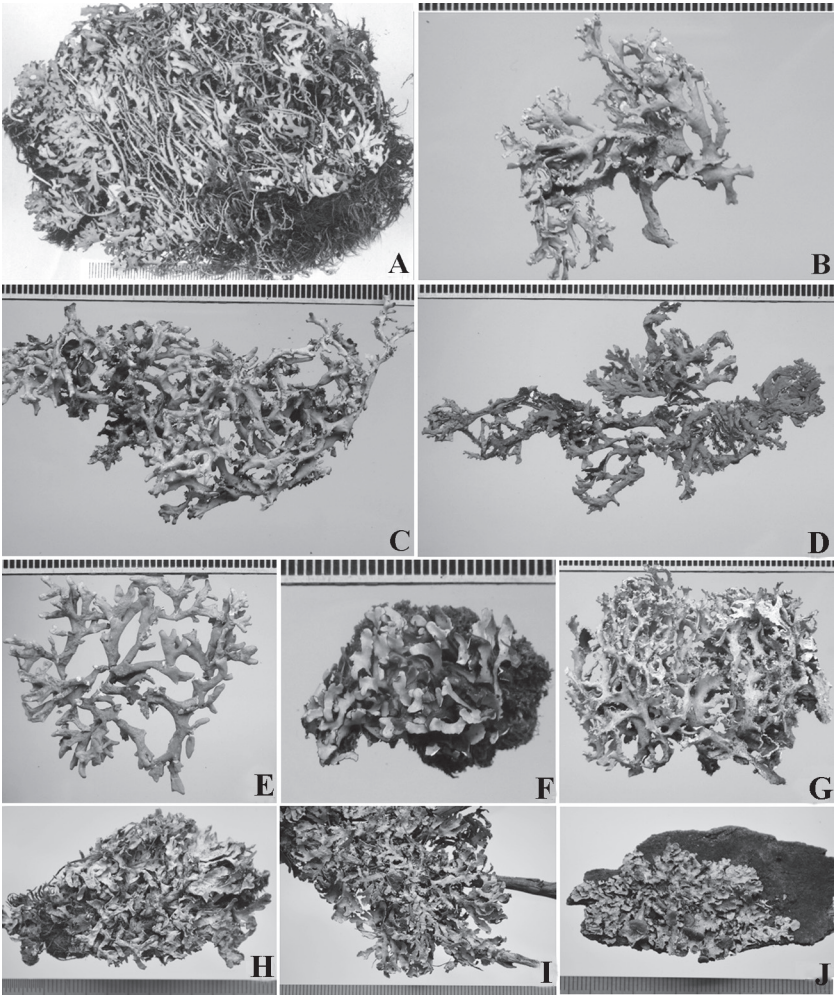

Plate 1. Habit of *Allocetraria* species. A. *A. ambigua* (HMAS-L 015005); B. *A. capitata* (isotype); C. *A. endochrysea* (HMAS-L 127390); D. *A. isidiigera* (holotype); E. *A. madreporiformis* (HMAS-L125691); F. *A. sinensis* (HMAS-L 127405); G. *A. stracheyi* (HMAS-L 015149); H. *A. flavonigrescens* (HMAS-L127395); I. *A. flavonigrescens* (HMAS-L 069642); J. *A. globulans* (HMAS-L015177). Scale in mm.

Species

Allocetraria ambigua (C. Bab.) Kurok. & M.J. Lai, Bull. Natl. Sci. Mus., Tokyo, B 17: 62, 1991. Plate 1A

Characterized by thin flat channeled lobes and a yellowish lower surface, *A. ambigua* is similar to *A. stracheyi*, which is distinguished by thick convex lobes and isidia-like lobules.

Chemistry—Usnic, lichesterinic, protolichesterinic, and secalonic acids.

Substrate—On soil or bark.

Distribution—China (Gansu, Shaanxi, Sichuan, Tibet and Yunnan provinces), India, Nepal.

Specimens examined: **CHINA**: **Gansu Prov.**: Mt. Minshan, alt. 4200 m, 23 August 1937, T.P. Wang 7582 (HMAS-L 014999); **Shaanxi Prov.**: Mt. Taibaishan, alt. 3200–3700 m, 12–13 July 1988, X.Q. Gao 3158 (HMAS-L 015003); X.Q. Gao 3185 (HMAS-L 015004); C.H. Ma 236 (HMAS-L 015000); C.H. Ma 238 (HMAS-L 015002); C.H. Ma 375 (HMAS-L 015005); alt. 3610 m, 23 July 2011, T. Zhang Z11136 (HMAS-L 127368); T. Zhang Z11139 (HMAS-L 127370); T. Zhang Z11144 (HMAS-L 127367); T. Zhang Z11145 (HMAS-L 127369); **Sichuan Prov.**: Mt. Gonggashan, alt. 4200 m, 29 July 1982, X.Y. Wang et al. 9046 (HMAS-L 015009); **Tibet**: Nyalam County, 12 June 1966, J.C. Wei & J.B. Chen 1441 (HMAS-L 015137); **Yunnan Prov.**: Deqen County, Mt. Baibaxueshan, alt. 4560 m, 16 September 2012, R.F. Wang BM12059 (HMAS-L 127372).

Allocetraria capitata R.F. Wang, Li S. Wang & J.C. Wei, Mycosystema 33: 21, 2014. Plate 1B

Characterized by having capitate soralia, *A. capitata* is similar to *A. isidiigera*, which is distinguished by its absence of soredia and presence of isidia.

Chemistry—Usnic, fumarprotocetraric, protocetraric, and secalonic acids.

Substrate—On soil, often over moss.

Distribution—China (Sichuan Province).

Specimens examined: **CHINA**: **Sichuan Prov.**: Dege Country, Manigangge villages, Mt Que'ershan, 31°55′N 98°56′E, alt. 4510 m, on moss, 30 August 2007, L.S. Wang et al. 07-28259 (KUN—holotype; HMAS-L—isotype).

Allocetraria corrugata R.F. Wang, X.L. Wei & J.C. Wei, **sp. nov.** Plate 2

Fungal Name FN 570087

Differs from *Allocetraria isidiigera* by its longer conidia, numerous black spots on the margin and upper surface, and strongly rugose upper and lower lobe surfaces.

Type—China, Yunnan Prov., Deqin Co., Meli village, Meili snow mountain, on rock, 28°38′N, 98°37′E, alt. 4400 m, 10 Sep. 2012, R.F. Wang 12033 (**Holotype**, HMAS-L).

Etymology—The epithet *corrugata* refers to the corrugated lobe surfaces.

Thallus foliose, adnate, dorsiventral; lobes narrow, 1–4 mm wide, slightly inflated, 200–450 μm thick, sublinear-elongate, sub-dichotomous to irregular branches, lobules irregularly branched; upper surface greenish yellow to

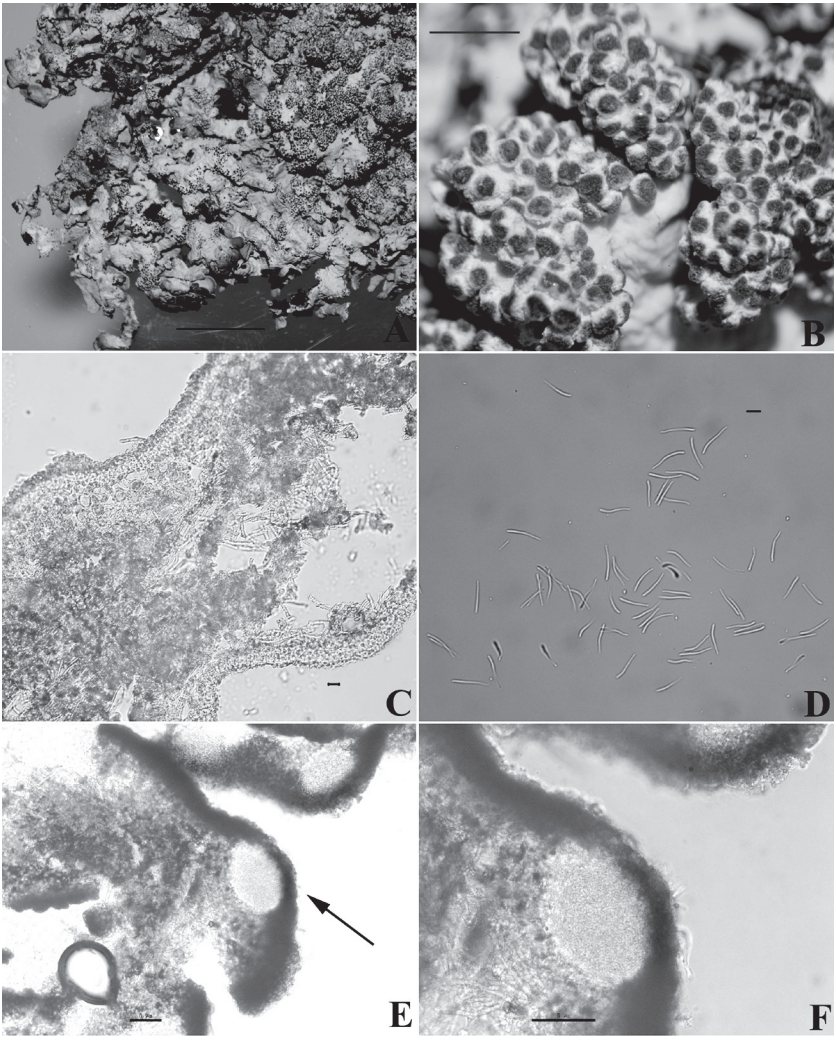

Plate 2. *Allocetraria corrugata* (holotype). A. Habit; B. The numerous black spots on the margin and upper surface; C. Longitudinal section of the thallus; D. Conidia; E. Longitudinal section of the thallus with black spots, hyphae inside and the arrow pointing at the location of one black spot; F. Magnification of the black spot pointed by the arrow in E. Scale bars: A = 1 cm; B = 1 mm; C, D = 20 μm; E, F = 5 μm.

green, strongly rugose, dark brown and whitish pruinose at the apices of lobes; spots dark brown to black, abundant, flush to emergent, scattered to crowded, mostly covered by white pruina; lower surface gray-white to pale brown, conspicuously rugose, rhizines marginal and laminal, concolorous with lower surface, sparse, unbranched, 1–4 mm long; pseudocyphellae rare, white, located on the ridges of the underside or on outgrowths; medulla white.

Upper cortex indistinct palisade plectenchymatous, 20–30 μm thick, composed of 3–6 layers; algal layer 25–50 μm; lower cortex paraplectenchymatous, 15–20 μm thick, composed of 3–4 layers; black spots at the upper surface not separated, composing of hyphae, the algal layer continuous. Apothecia not seen. Pycnidia frequent, both immersed and elevated on black projection, also at the top of isidia-like structures on the upper surface and margin, conidia colorless, filiform, one end slightly swollen, (12.5–)15–25(–30)×0.5–1.5 μm.

Chemistry—Cortex: K–, C–, KC+ yellow, PD–; medulla: K–, C–, KC–, PD+ yellow to red; containing usnic, fumarprotocetraric, and protocetraric acids (TLC).

Substrate—On rock, overgrowing mosses.

Distribution—Currently known only from Yunnan Province, China.

Allocetraria endochrysea (Lynge) Kärnefelt & A. Thell, Nova Hedwigia 62: 507, 1996. Plate 1C

Characterized by a subfruticose thallus with a yellow medulla, *A. endochrysea* is similar to *A. madreporiformis*, which is readily distinguished by its less-branched lobes, white medulla, and absence of dufourin and endochrysin.

Chemistry—Usnic, lichesterinic, and protolichesterinic acids, dufourin, endochrysin.

Substrate—On soil, overgrowing mosses.

Distribution—China (Sichuan and Yunnan provinces).

Specimens examined: **China**: **Sichuan Prov.**: Mt. Gonggashan, alt. 4400 m, 21 October 1999, L.H. Chen 990051 (HMAS-L 127380); L.H. Chen 990087-1 (HMAS-L 127382); **Yunnan Prov.**: Deqen County, Mt. Baibaxueshan, alt. 4350–4440 m, 16 September 2012, R.F. Wang BM12011 (HMAS-L 127385); R.F. Wang BM12040 (HMAS-L 127388); 22 September 2012, Q.M. Zhou et al. DQ12432-1 (HMAS-L 127387); alt. 4800 m, 10 September 2012, R.F. Wang YK12001 (HMAS-L 127384); R.F. Wang YK12003 (HMAS-L 127391); R.F. Wang YK12010 (HMAS-L 127390); R.F. Wang YK12013 (HMAS-L 127389).

Allocetraria flavonigrescens A. Thell & Randlane, Flechten Follmann Contr. Lich.: 359, 1995. Plate 1H, I

Characterized by long narrow channeled lobes, white medulla, and absence of pseudocyphellae, *A. flavonigrescens* is similar to *A. isidiigera,* which is distinguished by the presence of isidia.

Chemistry—Usnic, fumarprotocetraric, and protocetraric acids.

Substrate—On soil and corticolous on branches of *Rhododendron*.

Distribution—China (Qinghai, Shaanxi, Sichuan, Tibet, and Yunnan provinces), Nepal.

Specimens examined: **CHINA**: **Qinghai Prov.**: Maqin County, alt. 3970 m, 11 August 2012, X.L. Wei & K. Chen QH12058 (HMAS-L127395); X.L. Wei & K. Chen QH12407 (HMAS-L 128221); X.L. Wei & K. Chen QH12909 (HMAS-L 127447); Banma County, alt. 4299 m, 4 August 2012, X.L. Wei & K. Chen QH121141 (HMAS-L127394); **Shaanxi Prov.**: Mt. Taibaishan, alt. 3200 m, 12 July 1988, C.H. Ma 146 (HMAS-L 015094); alt. 3300 m, X.Q. Gao 3059 (HMAS-L 015091); X.Q. Gao 3051 (HMAS-L 015089); X.Q. Gao 3055 (HMAS-L 015092); alt. 3480 m, 23 July 2011, T. Zhang Z11121 (HMAS-L 128223); alt. 3360 m, 4 August 2005, J. Yang YJ218 (HMAS-L 069642); **Sichuan Prov.**: Mt. Zheduoshan, alt. 4200 m, 27 September 2007, L.S. Wang 07-28991 (KUN); **Tibet**: Mt. Dongdalashan, alt. 4950 m, HMAS-L 032363; **Yunnan Prov.**: Mt. Baibaxueshan, alt. 4560 m, R.F. Wang BM12062 (HMAS-L127396); R.F. Wang YK12036 (HMAS-L 126786); R.F. Wang YK12060 (HMAS-L 128222).

Allocetraria globulans (Nyl.) A. Thell & Randlane, Flechten Follmann Contr. Lich.: 360, 1995. Plate 1J

A corticolous species characterized by long narrow channeled flat lobes with corrugated margins, *A. globulans* is similar to *A. stracheyi*, which is distinguished by convex lobes.

Chemistry— Usnic, lichesterinic, protolichesterinic, and secalonic acids.

Substrate—On bark.

Distribution—China (Yunnan Province), Nepal.

Specimens examined: **CHINA**: **Yunnan Prov.**: Mt. Yulongxueshan, alt. 3820 m, 6 August 1981, X.Y. Wang et al. 6854 (HMAS-L015180); alt. 3380 m, 6 August 1981, X.Y. Wang et al. 6550 (HMAS-L015179); alt. 3950 m, 6 August 1981, X.Y. Wang et al. 5110 (HMAS-L015178); Mt. Baimaxueshan, alt. 2700 m, 12 July 1981, X.Y. Wang et al. 7781 (HMAS-L015177).

Allocetraria isidiigera Kurok. & M. J. Lai, Bull. Natl. Sci. Mus., Tokyo, B 17: 62, 1991. Plate 1D

Characterized by long narrow channeled lobes, a white medulla, and the absence of pseudocyphellae, *A. isidiigera* is similar to *A. flavonigrescens*, which is distinguished by the presence of isidia and slightly smaller conidia.

Chemistry— Usnic, fumarprotocetraric, and protocetraric acids.

Substrate—Corticolous on *Rhododendron* branches.

Distribution—China (Tibet), Nepal.

Specimens examined: **CHINA**: **Xizang (Tibet)**: Nyalam County, on *Rhododendron* stem, alt. 3910 m, J.C. Wei & J.B. Chen 1857 (Holotype, HMAS-L).

Allocetraria madreporiformis (Ach.) Kärnefelt & A. Thell, Nova Hedwigia 62: 508, 1996. Plate 1E

Characterized by a subfruticose thallus, erect lobes, and a white medulla, *A. madreporiformis* is similar to *A. endochrysea*, which is distinguished by a yellow medulla and the presence of dufourin and endochrysin.

Chemistry—Usnic and lichesterinic acids.

Substrate—On soil.

Distribution—China (Xinjiang Uygur Autonomous Region), Mongolia, Turkistan, West of North America, Central Europe.

Specimens examined: **CHINA**: **Xinjiang Uygur Autonomous Region**: Mt. Tianshan, alt. 3200 m, 20 July 1978, X.Y. Wang 0950 (HMAS-L006687); 28 May 2011, J.C. Wei s.n. (HMAS-L125691); alt. 3000 m, 3 July 1997, X.Y. Wang 367 (HMAS-L006685).

Allocetraria sinensis X.Q. Gao, Flechten Follmann Contr. Lich.: 365, 1995. Plate 1F

Characterized by an erect thallus, long narrow channeled lobes, and a glossy lower surface, *A. sinensis* resembles *A. ambigua*, which can be distinguished by its yellowish lower surface.

Chemistry—Usnic, lichesterinic, protolichesterinic, and secalonic acids.

Substrate—On soil.

Distribution—China (Shaanxi, Sichuan, Yunnan, and Tibet), Nepal.

Specimens examined: **CHINA**: **Shaanxi Prov.**: Mt. Taibaishan, alt. 3400 m, on ground, X.Q. Gao 3052 (Holotype, HMAS-L); alt. 3550 m, 13 July 1988, X.Q. Gao 3178 (HMAS-L 014992); **Sichuan Prov.**: Mt. Gonggashan, alt. 2850 m, 24 June 1982, X.Y. Wang et al. 8260 (HMAS-014986); Mt. Balangshan, alt. 4300 m, 18 August 1982, X.Y. Wang et al. 9544 (HMAS-014990); X.Y. Wang et al. 9496 (HMAS-L 014988); **Tibet**: Zuogong County, alt. 4500 m, 8 October 1982, J.J. Su 5381 (HMAS-L014995); **Yunnan Prov.**: Mt. Yulongxueshan, alt. 3970 m, 6 August 1981, X.Y. Wang et al. 7076 (HMAS-L 014996); Mt. Baimaxueshan, 16 September 2012, R.F. Wang YK12006 (HMAS-L 127405); R.F. Wang YK12008 (HMAS-L 127410); R.F. Wang YK12025 (HMAS-L 127406).

Allocetraria stracheyi (C. Bab.) Kurok. & M.J. Lai, Bull. Natl. Sci. Mus., Tokyo, B 17: 62, 1991. Plate 1G

Characterized by thick raised lobes and a yellowish lower surface, *A. stracheyi* is similar to *A. ambigua,* which differs in its thin flat lobes, and *A. capitata,* which differs in the presence of soredia.

Chemistry.—Usnic, lichesterinic, protolichesterinic, and secalonic acids.

Substrate—On soil and branches of shrubs.

Distribution—China (Shaanxi, Sichuan, Xinjiang Uygur Autonomous Region, Yunnan, and Tibet), India, Nepal, North America.

Specimens examined: **CHINA**: **Shaanxi Prov.**: Mt. Taibaishan, alt. 3600 m, 13 July 1988, X.Q. Gao 3151 (HMAS-L 015174); **Sichuan Prov.**: Mt. Gonggashan, alt. 3700–3800 m,

27 June 1982, X.Y. Wang et al. 8354 (HMAS-L 015161); Mt. Balangshan, alt. 4300 m, 18 August 1982, X.Y. Wang et al. 9488 (HMAS-L 015168); **Tibet**: Zuogong County, alt. 4400 m, 8 October 1982, J.J. Su 5387 (HMAS-L015155); **Yunnan Prov.**: Mt. Baimangxueshan, alt. 4300 m, 29 August 1981, X.Y. Wang et al. 7546 (HMAS-L 029482); Mt. Daxueshan, alt. 4250 m, 8 September 1981, X.Y. Wang 7209 (HMAS-L015154); alt. 4330–4800 m, 8 August 1982, J.J. Su 5410 (HMAS-L 015149); Deqen County, 16 September 2012, R.F. Wang BM12029 (HMAS-L 127423); R.F. Wang YK12005 (HMAS-L 127428); R.F. Wang YK12009 (HMAS-L 127418); R.F. Wang YK12016 (HMAS-L 127427); R.F. Wang YK12030 (HMAS-L 127430); R.F. Wang DQ12432 (HMAS-L 127424); **Xinjiang Uygur Autonomous Region**: Mt. Tianshan, alt. 3200 m, 20 July 1978, X.Y. Wang 949 (HMAS-L 007697).

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